

LONG-TERM AVERAGES, VARIABILITY FACTORS, AND LIMITATIONS AND STANDARDS

This chapter describes the data selected and statistical methodology used by EPA in calculating the long-term averages, variability factors, and limitations. Effluent limitations and standards¹ for each subcategory are based on long-term average effluent values and variability factors that account for variation in treatment performance within a particular treatment technology over time. This chapter replaces the discussion of how limitations were determined in the 1995 statistical support document.²

FACILITY SELECTION

10.1

In determining the long-term averages and limitations for each pollutant of concern and each subcategory option, EPA first evaluated information about individual facilities and the analytical data from their treatment systems. As a result of this evaluation, EPA selected only those facilities that operated the model technology to achieve adequate pollutant removals for use in calculating subcategory long-term averages and limitations. EPA used data from the appropriate influent and effluent sample points to develop the long-term averages, variability factors, and limitations. Table 10-1 identifies these facilities and sampling points for the proposed options. The EPA sampling episodes are identified with an 'E' preceding the

facility's 4-digit number (for example, E4378). Data supplied by the facilities ("self-monitoring data") are not preceded by any alphabetic character (for example, facility 602). The table includes some options that EPA did not use as the basis for the proposed limitations. These are included because the data are listed in Appendix C and/or in items in the record for the proposed rulemaking.

EPA selected some facilities for more than one subcategory option if the facility treated its wastes using more than one of the model technologies. For example, EPA selected facility 4378 for both options 2 and 3 in the Metals subcategory because the effluent from sample point SP07 represents the option 2 model technology and the effluent from SP09 represents the option 3 model technology. For the Oils subcategory, facilities 4814A, 4814B, and 701 had the model technology for option 8. The model technology for option 9 is a combination of the option 8 model technology and an additional pretreatment step of gravity separation and are based on facilities 4813, 4814A, 4814B, and 701. Even though the technology basis for Option 9 is based on an additional treatment step, EPA included the data from the option 8 facilities to ensure that the limitations were based on facilities which treat the full breadth of pollutants and pollutant concentrations found in oils subcategory wastes. Thus, EPA selected these facilities to characterize both the model technology for options 8 and 9.

If the concentration data from a facility was collected over two or more distinct time periods, EPA analyzed the data from each time period

¹In the remainder of this chapter, references to 'limitations' includes 'standards.'

²*Statistical Support Document For Proposed Effluent Limitations Guidelines And Standards For The Centralized Waste Treatment Industry*, EPA 821-R-95-005, January 1995.

separately. In the documentation, EPA identifies each time period with a distinct “facility” identifier. For example, facilities 4378 and 4803 are actually one facility, but the corresponding data are from two time periods. In effluent guidelines for other industrial categories, EPA has made similar assumptions for such data, because data from different time periods generally characterize different operating conditions due to changes such as management, personnel, and procedures.

Further, if EPA obtained the concentration data from both an EPA sampling episode and self-monitoring data provided by the facility, EPA analyzed the data from each source separately. Again, this is similar to assumptions that EPA has made for effluent guidelines for other industrial categories. The exception to this general rule was for facility 701 in which EPA combined data that EPA and the facility collected during overlapping time periods. The facility provided effluent measurements collected on four consecutive days by the control authority and monthly effluent measurements collected by the facility. EPA, however, only collected influent and effluent measurements on one day. (In Table 10-1, the data from the facility are identified as ‘701.’ The EPA sampling data is identified as ‘E5046.’ In this document, the data from the two sources are collectively identified as ‘facility 701.’) EPA believes that it is inappropriate to include the effluent measurements from E5046 in its calculations because the sample was collected as a grab sample rather than as a composite sample of the continuous flow system at that sample point. However, EPA retained the influent measurements because influent measurements were otherwise unavailable and this information was crucial for determining if the facility accepted wastes containing the pollutants that were measured in the effluent. EPA also used this influent information in evaluating the pollutant removals for facility 701.

Although EPA collected the data for Episode 4814 during the same time period and from the same facility, EPA has determined that data from facility 4814 should be used to characterize two separate facilities. Facility 4814 has two entirely separate treatment trains which EPA sampled separately. Because the systems were operated separately and treated different wastes, EPA has treated the data as if they were collected from two different facilities (EPA has identified the systems as 4814A and 4814B)

SAMPLE POINT SELECTION ***10.2***

Effluent Sample Point ***10.2.1***

For each facility, EPA determined the effluent sample point representing wastewater discharged by the model technology selected as the basis for that subcategory option. For example, the effluent discharged from sample point SP09 at facility 4378 is the effluent resulting from the model technology selected for option 3 of the Metals subcategory.

Influent Sample Point ***10.2.2***

Influent data were available for all EPA sampling episodes. However, relevant influent data were not available for any of the self-monitoring effluent data except for Facility 701 (as explained in section 10.1). As detailed previously in Chapter 12, for the metals and organics subcategories, this influent data represent pollutant concentrations in “raw”, untreated wastes. For the oils subcategory, however, influent data represent pollutant concentrations following emulsion breaking/gravity separation. Therefore, for each facility, EPA determined the relevant influent sample point for the waste entering the model technology selected as the basis for that subcategory option.

In some cases, EPA estimated influent pollutant concentrations by combining pollutant measurements from two or more influent sample

points into a single flow-weighted value. For example, in Option 3 of the metals subcategory, EPA collected influent samples at five points (SP01, SP03, SP05, SP07, and SP10) during the sampling episode at Facility 4803. EPA calculated a single value from these five sampling points representing the influent to the model technology using the methodology described in Section 10.4.3.3.

Special Cases

10.2.3

As detailed previously in Chapter 2, for samples collected during EPA sampling episodes, EPA did not analyze for the full spectrum of pollutants at each sampling point. The specific constituents analyzed at each episode and sampling point varied and depended on the waste type being treated and the treatment technology being evaluated. For example, for the metals subcategory, EPA did not generally analyze for organic pollutants in effluent from chemical precipitation and clarification. Therefore, in some cases, for specific pollutants, EPA selected a different sample point to represent influent to and effluent from the model treatment technology than the sample point selected for all other pollutants. For example, for Episode 4803 in Metals Option 3, EPA selected sample point 15 to represent the effluent from the model technology. Since EPA did not analyze the wastewater collected at sample point 15 for oil and grease, sgt-hem, total cyanide, and organic constituents, for these pollutants only, EPA selected sample point 16 to represent the effluent point for Episode 4803 of Metals Option 3. EPA believes this is appropriate since the treatment step between sample point 15 and sample point 16 should not have affected the levels of these pollutants in the wastewater.

DETERMINATION OF BATCH AND CONTINUOUS FLOW SYSTEMS

10.3

For each influent and effluent sample point of

interest, EPA determined whether wastewater flows were ‘*continuous*’ or ‘*batch*.’ At sample points associated with continuous flow processes, EPA collected composite samples for all analytes except for oil and grease (for which the analytical methods specify grab samples). At sample points associated with batch flow processes, EPA collected grab samples. For self-monitoring data, EPA assumed the wastewater flow to be either continuous or batch based on the type of discharge at the facility (i.e., continuous or batch discharge).

EPA made different assumptions depending on the two types of flow processes. For a sample point associated with a continuous flow process, EPA aggregated all measurements within a day to obtain one value for the day. This daily value was then used in the calculations of long-term averages, variability factors, and limitations. For example, if samples were collected at the sample point on four consecutive days, the long-term average would be the arithmetic average of four daily values. (Sections 10.4.2 and 10.5 discuss data aggregation and calculation of long-term averages, respectively.) In contrast, for a sample point associated with a batch flow process, EPA aggregated all measurements within a batch to obtain one value for the batch process. This batch value was then used as if it were a daily value. For example, if one sample was collected from each of 20 batches treated on four consecutive days (i.e., a total of 20 samples during a four day period), the long-term average would be the arithmetic average of the 20 batch values. For simplicity, the remainder of the chapter refers to both types of aggregated values (i.e., daily and batch values) as ‘daily values.’ In addition, references to ‘sampling day’ or ‘day’ mean either a sampling day at a continuous flow facility or a batch from a batch flow facility. The sample points followed by an asterisk in Table 10-1 are associated with batch flow systems. EPA assumed all other sample points to be associated with continuous flow systems.

Table 10-1 Facilities and Sample Points Used to Develop Long-term Averages and Limitations

Subcategory	Option	Facility	Pollutants	Effluent Sample Point	Influent Sample Point
Metals	1A	E1987	All	SP03	SP01, SP02 <u>day3 flows:</u> SP01=2500gal SP02=1290gal (on other days, samples weren't collected at both sample points.)
		E4382	All	SP12	SP07
		613	analytes that pass tests in E4382	SP16 *	none
		E4798	All	SP03	SP02
	2	E4378	Total cyanide	SP07	SP06
			Organics	SP07	SP08
			All others	SP07	SP01= 5,000 gal * SP03=20,000 gal *
	3	E4378	Total cyanide	SP09	SP06
			Organics	SP09	SP08
			All others	SP09	SP01= 5,000 gal SP03=20,000 gal
		602	Analytes passing the tests in E4378 OR E4803	SP01	none
		E4803	Oil and Grease, SGT-HEM, total cyanide, and organics	SP16	SP12
			All others	SP15	SP01= 3,400 gal * SP03=12,600 gal * SP05=18,000 gal * SP07= 8,000 gal * SP10= 4,355 gal * ‡
	4	E4798	All	SP05	SP02
		700	Analytes passing the tests in E4798	SP01	none
Cyanide Subset of Metals Subcategory	1	E4393	Total cyanide	SP07	SP06
	2	E4055	Total cyanide	SP03 *	SP02 *
Oils	1C	E4381	All	SP01 *	none
		E4382	All	SP11	none
		E4440	All	SP06	none
		E4620	All	SP02	none
		E4813	Total cyanide	SP06	none
			All others	SP05	none
		E4814A	All	SP07	none
		E4814B	All	SP08	none
	8/8v	E4814A	All	SP09	SP07
		E4814B	All	SP10	SP08
		701 and E5046 †	All	SP01 from 701	none from 701 and SP01 from E5046

Table 10-1 Facilities and Sample Points Used to Develop Long-term Averages and Limitations

Subcategory	Option	Facility	Pollutants	Effluent Sample Point	Influent Sample Point
Oils (cont.)	9/9v	E4813	Total cyanide	SP07	SP06
			All others	SP07	SP05
		E4814A	All others	SP09	SP07
		E4814B	All	SP10	SP08
		701 and E5046 †	All	SP01 from 701	none from 701 and SP01 from E5046
Organics	0	E4377	All	SP01	none
		E4472	All	SP01	none
	3/4	E1987	All	SP12	SP07B

* Batch flow systems. All others are continuous flow systems.

‡ EPA collected samples from four separate batches at SP10. The flows associated with the four batches 10A, 10B, 10C, and 10D were 3500 gal, 5130 gal, 3500 gal, and 5130 gal, respectively. EPA used the average flow of 4355 gal in flow-weighting SP10 with the four other sample points SP01, SP03, SP05, and SP07.

† These are identified as facility 701 in other tables in this document and in the record.

When multiple sample points are identified in this table, the data listing and data summaries identify the last sample point. For example, for facility 4803 (metals subcategory, option 3), the influent sample point is identified as 'SP10.'

DATA SELECTION

10.4

EPA performed a detailed review of the analytical data and sampling episode reports. As a result, EPA corrected some errors in the database. EPA also re-evaluated the bases for the data exclusions and assumptions as used in calculating limitations for the 1995 proposal. EPA made some modifications to its approach for this proposal after reviewing the assumptions it used for excluding or modifying certain data. These are discussed in this section. The database was corrected and the corrected version has been placed in the record to this proposed rulemaking.

Data Exclusions and Substitutions 10.4.1

In some cases, EPA did not use all of the data detailed in Table 10-1 to calculate long-term averages, variability factors and limitations. This section details these data exclusions and substitutions Other than the data exclusions and substitutions described in this section and those resulting from the data editing procedures

(described in section 10.4.3), EPA has used all the data from the facilities and sample points presented in Table 10-1.

Operational Difficulties 10.4.1.1

EPA excluded data that were collected while the facility was experiencing operational difficulties. For the data used in calculating long-term averages and limitations, this occurred during sampling at episode 4814 only. During the second day of sampling, 9/17/96, the facility was required to shut-down and re-start the operation of both of their DAF systems due to poor performance and equipment failures. As such, EPA excluded all data collected on 9/17/97 associated with sample point 09 at facility 4814A and sample point 10 at facility 4814B.

Treatment Not Reflective of BPT/BCT/BAT Treatment 10.4.1.2

EPA reviewed the effluent data used to develop the limitations and excluded any facility data set where the long-term average did not reflect the performance expected by

BPT/BCT/BAT treatment. Other than excluding mercury values from facility 602 in option 3 of the metals subcategory, the other excluded facility data sets were for conventional parameters (i.e., oil and grease, BOD₅, and TSS). In all cases, these data sets were collected at facilities that are indirect dischargers and that are not required to optimize performance of their system for removal of these pollutants. In most cases, the conventional pollutants are not limited by the POTW and the facility is not required to monitor for these pollutants. These exclusions were for oil and grease (facilities 4813, 4814A, and 4814B for option 9³ of the oils subcategory), BOD₅ (facility 1987 for option 3/4 of the organics subcategory), TSS (facility 1987 for option 3/4 of the organics subcategory, and facilities 4798 and 700 for option 4 of the metals subcategory).

Similarly, in calculating long-term averages for oils option 9, EPA excluded the TSS data for facilities 4813, 4814A, and 4814B. However, EPA used these data to calculate variability factors for TSS for oils option 9 since EPA believes that the data reflected the overall variability associated with the model technology. (Sections 10.5, 10.6, and 10.7 describe the development of the long-term averages, variability factors, and limitations, respectively.)

*Exclusions to EPA Sampling Data
Based Upon the Availability of the
Influent and Effluent*

10.4.1.3

For the data from the EPA sampling episodes, EPA determined the availability of the influent and effluent data for each sampling day. Both influent and effluent levels are important in evaluating whether the treatment system efficiently removed the pollutants. In addition, the pollutant levels in the influent indicate

whether the pollutants existed at treatable levels. In most cases, influent and effluent data were both available for a given day.

For the cases when effluent data were unavailable for some days, but influent data were available, EPA generally determined that the influent data still provided useful information about the pollutant levels and should be retained. However, for the organic pollutants at facility 4378, the effluent data were only available for one day while the influent data were available for several days. In this case, EPA determined that the influent levels on that single date should be considered and the levels on the other dates excluded.

When the effluent data were available but influent data were unavailable, EPA determined that the effluent data should be excluded from further consideration. Without the influent data, EPA could not evaluate the treatability of the pollutants and the effectiveness of the treatment system.

More Reliable Results Available *10.4.1.4*

In some cases, EPA had analytical data which represent a single facility (and time period) that were analyzed by two different laboratories or using two different analytical methods. For two of these cases, EPA determined that one analytical result was more reliable than the other and excluded the less reliable result. This section describes these cases.

In limited instances, facility 700 provided two analytical results for the same date from different laboratories. For the total cyanide effluent data collected on 11/6/96, the analytical results from the two laboratories differed considerably. The facility representative considered the result generated by the off-site laboratory to be more reliable than the result generated by the facility's on-site laboratory and recommended that EPA use the off-site data only. EPA agrees with this suggestion and has used only the value from the off-site laboratory.

³EPA did not similarly exclude data for facilities 4814A and 4814B from the Option 8 calculations since EPA did not select this option as the basis of the proposed BPT/BCT limitations.

Some chlorinated phenolics in episode 1987 were analyzed by both method 85.01 and method 1625. Thus, for a given sample, there were two results for a specific chlorinated phenolic. Of the pollutants of concern, these compounds were pentachlorophenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol. Where two results were provided for the same pollutant in a sample, EPA used the analytical result from Method 1625. This decision is based on the knowledge that Method 1625 is an isotope dilution GC/MS procedure, and therefore produces more reliable results than Method 85.01.

*Data from Facilities Which
Accepted Waste from More
than One Subcategory*

10.4.1.5

EPA also excluded data that were collected during time periods when the facility treated wastes from more than one CWT subcategory. For the oil and grease calculations for metals option 4, EPA excluded all oil and grease values greater than 143 mg/L since this was the highest value of oil and grease measured in the *influent* samples collected at any metals subcategory facility. EPA believes that values of oil and grease in the *effluent* above this level indicate that the facility was also treating oils subcategory wastes and has, therefore, excluded this data from its calculations.

*Substitution Using the
Baseline Values*

10.4.1.6

In developing the pollutant long-term averages and limitations, EPA compared each laboratory-reported sample result to a baseline value (defined in Chapter 15). For certain pollutants, EPA substituted a larger value than the measured value or sample-specific detection limit in calculating the long-term averages and limitations. These pollutants were measured by Methods 1624 and 1625 (organic pollutants) and Method 1664 (n-hexane extractable material (HEM) and silica gel treated n-hexane extractable

material (sgt-hem)). For these pollutants, EPA substituted the value of the minimum level (ML) specified in the method and assumed that the measurement was non-detected when a measured value or sample-specific detection limit was reported with a value less than the ML. For example, if the ML was 10 ug/l and the laboratory reported a detected value of 5 ug/l, EPA assumed that the concentration was non-detected with a sample-specific detection limit of 10 ug/l. For all other pollutants, EPA used the reported measured value or sample-specific detection limit.

Data Aggregation

10.4.2

In some cases, EPA determined that two or more samples had to be mathematically aggregated to obtain a single value. In some cases, this meant that field duplicates, grab samples, and/or multiple daily observations were aggregated for a single sample point. In other cases, data from multiple sample points were aggregated to obtain a single value representing the influent to the model technology.

In all aggregation procedures, EPA considered the censoring type associated with the data. EPA considered measured values to be *detected*. In statistical terms, the censoring type for such data was 'non-censored' (NC). Measurements reported as being less than some sample-specific detection limit (e.g., <10 mg/L) are censored and were considered to be *non-detected* (ND). In the tables and data listings in this document and the record for the proposed rulemaking, EPA has used the abbreviations NC and ND to indicate the censoring types.

The distinction between the two censoring types is important because the procedure used to determine the variability factors considers censoring type explicitly. This estimation procedure modeled the facility data sets using the modified delta-lognormal distribution. In this distribution, data are modeled as a mixture of two distributions corresponding to different process

conditions. Because this industry treats different types of waste from day to day, EPA assumed that the process conditions leading to non-detected values are generally different than process conditions leading to the detected values. (For example, a facility may treat wastewater with relatively high levels of organics and low levels of metals and the next day treat wastes that have high metals concentrations and non-detectable levels of organics.) Thus, the distinctions between detected and non-detected measurements were important in estimating the variability factors.

Because each aggregated data value entered into the model as a single value, the censoring type associated with that value was also important. In many cases, a single aggregated value was created from unaggregated data that were all either detected or non-detected. In the remaining cases with a mixture of detected and non-detected unaggregated values, EPA determined that the resulting aggregated value should be considered to be detected because the pollutant was measured at detectable levels.

This section describes each of the different aggregation procedures. They are presented in the order that the aggregation was performed. That is, field duplicates were aggregated first, grab and multiple samples second, and finally multiple streams. For example, if EPA has four pairs of data (i.e., four influent samples and four duplicate influent samples), then EPA aggregated each of the four pairs to obtain four values -- one for each pair of data. These four values were then aggregated to obtain one daily value for the influent stream. As a further example, suppose the same facility had two additional streams entering into the treatment system. Thus, the influent into the treatment system would be characterized by the combination of the pollutant levels of the three streams. To obtain one value to characterize the influent, the pollutant levels in the three streams would be '*flow-weighted*' by the wastewater flow in each stream. The

following three sections specify the procedures used to aggregate field duplicates, grab samples (and daily values), and multiple influent streams, respectively.

Aggregation of Field Duplicates 10.4.2.1

During the EPA sampling episodes, EPA collected a small number of field duplicates. Generally, ten percent of the number of samples collected were duplicated. Field duplicates are two or more samples collected for the same sampling point at approximately the same time, assigned different sample numbers, and flagged as duplicates for a single sample point at a facility. Because the analytical data from each duplicate pair characterize the same conditions at that time at a single sampling point, EPA aggregated the data to obtain one data value for those conditions. The data value associated with those conditions was the arithmetic average of the duplicate pair. In most cases, both duplicates in a pair had the same censoring type. In these cases, the censoring type of the aggregate was the same as the duplicates. In the remaining cases, one duplicate was a non-censored value and the other duplicate was a non-detected value. In these cases, EPA determined that the appropriate censoring type of the aggregate was 'non-censored' because the pollutant had been present in one sample. (Even if the other duplicate had a zero value⁴, the pollutant still would have been present if the samples had been physically combined.) Table 10-2 summarizes the procedure for aggregating the analytical results from the field duplicates. This aggregation step for the duplicate pairs was the first step in the aggregation procedures for both influent and effluent measurements.

⁴This is presented as a 'worst-case' scenario. In practice, the laboratories cannot measure 'zero' values. Rather they report that the value is less than some level (see chapter 15).

Table 10-2. Aggregation of Field Duplicates

If the field duplicates are:	Censoring type of average is:	Value of aggregate is:	Formulas for aggregate value of duplicates:
Both non-censored	NC	arithmetic average of measured values	$(NC_1 + NC_2)/2$
Both non-detected	ND	arithmetic average of sample-specific detection limits	$(DL_1 + DL_2)/2$
One non-censored and one non-detected	NC	arithmetic average of measured value and sample-specific detection limit	$(NC + DL)/2$
NC=non-censored (or detected) ND=non-detected DL=sample-specific detection limit			

Aggregation of Grab Samples and Multiple Daily Values

10.4.2.2

This section describes the aggregation of grab samples and multiple daily values for effluent sample points associated with continuous flow facilities (defined in section 10.3).

During the EPA sampling episodes, EPA collected two types of samples: grab and composite. Typically, for a continuous flow system, EPA collected composite samples; however, for oil and grease, the method specifies that grab samples must be used. For that pollutant, EPA collected four grab samples during a sampling day at a sample point associated with a continuous flow system. To obtain one value characterizing the pollutant levels at the sample point on a single day, EPA mathematically aggregated the measurements from the grab samples.

In the self-monitoring data, facilities occasionally reported more than one value for a single day. If the sample point was associated with a continuous flow system, then EPA mathematically aggregated the results to obtain one daily value.

EPA used the same procedure for grab samples and multiple daily values. The method arithmetically averaged the measurements to obtain a single value for the day. When one or more measurements were non-censored, EPA

determined that the appropriate censoring type of the aggregate was 'non-censored' because the pollutant was present. Table 10-3 summarizes the procedure.

Table 10-3 Aggregation of Grab Samples and Daily Values

If the grab or multiple samples are:	Censoring type of Daily Value is:	Daily value is:	Formulas for Calculating Daily Value:
All non-censored	NC	arithmetic average of measured values	$\frac{\sum_{i=1}^n NC_i}{n}$
All non-detected	ND	arithmetic average of sample-specific detection limits	$\frac{\sum_{i=1}^n DL_i}{n}$
Mixture of non-censored and non-detected values (total number of observations is n=k+m)	NC	arithmetic average of measured values and sample-specific detection limits	$\frac{\sum_{i=1}^k NC_i + \sum_{i=1}^m DL_i}{n}$

NC=non-censored (or detected) ND=non-detected DL=sample-specific detection limit

Aggregation of Data Across Streams (“Flow-Weighting”)

10.4.2.3

After field duplicates and grab samples were aggregated, the data were further aggregated across sample points. This step was necessary when more than one sample point characterized the wastestream of concern. For example, this situation occurred for facility 4803 where five different wastestreams entered into the treatment process. EPA sampled each of these wastestreams individually at sample points SP01,

SP03, SP05, SP07, and SP10. In aggregating values across sample points, if one or more of the values were non-censored, then the aggregated result was non-censored (because the pollutant was present in at least one stream). When all of the values were non-detected, then the aggregated result was considered to be non-detected. The procedure for aggregating data across streams is summarized in Table 10-4. The following example demonstrates the procedure for hypothetical pollutant X at a facility with three streams entering into the treatment system.

Example of calculating an aggregated flow-weighted value:

Sample Point	Flow (gal)	Concentration (ug/L)	Censoring
SP33	10,000	10	ND
SP34	20,000	50	NC
SP35	5,000	100	ND

Calculation to obtain aggregated, flow-weighted value:

$$\frac{(10,000 \text{ gal} * 10 \text{ ug/L}) + (20,000 \text{ gal} * 50 \text{ ug/L}) + (5,000 \text{ gal} * 100 \text{ ug/L})}{10,000 \text{ gal} + 20,000 \text{ gal} + 5,000 \text{ gal}} = 45.7 \text{ ug/L}$$

because one of the three values was non-censored, the aggregated value of 45.7 ug/L is non-censored.

Table 10-4 Aggregation of Data Across Streams

If the n observations are:	Censoring type is:	Formulas for value of aggregate
All non-censored	NC	$\frac{\sum_{i=1}^n NC_i \times flow_i}{\sum_{i=1}^n flow_i}$
All non-detected	ND	$\frac{\sum_{i=1}^n DL_i \times flow_i}{\sum_{i=1}^n flow_i}$
Mixture of k non-censored and m non-detected (total number of observations is n=k+m)	NC	$\frac{\sum_{i=1}^k NC_i \times flow_i + \sum_{j=1}^m DL_j \times flow_j}{\sum_{i=1}^n flow_i}$

NC=non-censored (or detected)

ND=non-detected

DL=sample-specific detection limit

Data Editing Criteria

10.4.3

After excluding some data (as detailed in Section 10.4.1) and aggregating the data, EPA applied data editing criteria to select facility data sets from the EPA sampling episodes to use in calculating the long-term averages and limitations. These criteria were specified by the 'long-term average test' and 'percent removals

test.' In addition, the criteria for the self-monitoring data depended upon the results of the data editing criteria for the data that EPA collected at the facilities. These data editing criteria are described in the following sections. When the influent data at a facility failed the editing criteria, EPA excluded the effluent data for the facility in calculating the long-term averages and limitations for the corresponding

option in the subcategory. For example, at facility 1987, if the arsenic data from influent sample point 07B failed any of the editing criteria, then the effluent data at sample point SP12 were excluded from calculating the long-term averages and limitations for option 4 of the organics subcategory. For each of the proposed options and pollutants of concern evaluated for long-term averages and limitations, Attachment 10-1 indicates whether the data failed the data editing criteria, indicates when no data were available for a pollutant at any of the facilities, or provides the facility-specific long-term average (calculated as described in section 10.5).

Long-Term Average Test 10.4.3.1

EPA established the long-term average test ('LTA test') to ensure that the pollutants were present in the influent at sufficient concentrations to evaluate treatment effectiveness at the facility. After the data aggregation described in section 10.4.2, EPA compared the daily values of the influent and their long-term average to the baseline values described in chapter 15. The influent had to pass one of the following two steps to pass the LTA test:

- Step 1: Fifty percent of the influent measurements had to be detected at concentration levels equal to or greater than ten times the baseline value for the pollutant (these values are listed in Attachment 15-1); or
- Step 2: The influent long-term average had to be equal to or greater than ten times the baseline value and at least 50 percent of the influent measurements had to be detected (at any level). Section 10.5 describes the calculations for long-term averages.

Percent Removal Test 10.4.3.2

If the influent data passed either step in the LTA test, then EPA calculated the facility's influent and effluent averages without all of the data aggregation steps described in section 10.4.2. This is a deviation from the procedure used to calculate the influent averages used in LTA test (in section 10.4.3.1) and the effluent long-term averages used in the limitations (in section 10.7). For the percent removals, EPA used a different aggregation procedure that emphasized the detection of pollutant levels. In this modified aggregation procedure, EPA aggregated field duplicates using the procedure in section 10.4.2.1 and flow weighted wastestreams using the procedure in Section 10.4.2.3. EPA did not aggregate batches, grabs, or multiple daily values (other than duplicates) as an interim step prior to obtaining one overall value for the wastestream. For example, if a facility had five influent measurements of which three were batches from sample point 33 and the remaining two were a duplicate pair at sample point 34, EPA first aggregated the duplicate measurements at sample point 34 to obtain one value for the duplicate pair. EPA then arithmetically averaged the three batches from sample point 33 without considering the flows corresponding to each batch. For the percent removals, the influent average was then the flow-weighted average of two values: one from sample point 33 and one from sample point 34. In contrast, the influent average for the LTA test would have flow-weighted the batches from sample point 33 using the flows for each batch.

The percent removal test compared the influent and effluent averages to determine if the treatment associated with the effluent sample point removed any of the pollutant. If the removals were negative, then EPA excluded the effluent data from developing the long-term averages and limitations.

$$\text{Percent removal} = \frac{\text{Influent average} - \text{Effluent average}}{\text{Influent average}} \times 100$$

Evaluation of Self-Monitoring Data 10.4.3.3

EPA used self-monitoring data for effluent at three facilities in developing the long-term averages and limitations. These facilities were 602, 700, and 701. These facilities provided concentration values for some of the pollutants that EPA considered in developing the long-term averages and limitations. However, the self-monitoring data were for effluent only (i.e., no influent data were provided). In its evaluation of the data, EPA determined that influent data provided critical evidence that the facility treated wastes containing these pollutants. Thus, EPA used influent data from its sampling episodes to determine if the facility accepted wastes containing these pollutants.

For facility 701, EPA collected influent information during the same time period as the effluent data provided by the facility. As described in section 10.1, EPA used this influent information with the facility 701 effluent data.

For the remaining two facilities, 602 and 700, EPA considered the pollutant levels in the influent at the EPA sampling episodes. As explained in section 10.1, different facility numbers may refer to the same facility. For example, for option 3 of the metals subcategory, facilities 602, 4378, and 4803 are the same facility. (Facilities 4378 and 4803 were EPA sampling episodes.) If the influent data at facility 4378 or facility 4803 met the data editing criteria (i.e., LTA test and percent removals test), then EPA used the effluent data from facility 602 in calculating the long-term averages and limitations for the pollutant. If the influent data for the pollutant at facility 4378 and facility 4803 did not meet the criteria, then EPA excluded the data

from facility 602. In a similar manner, facilities 4798 and 700 for option 4 of the metals subcategory were linked. If the influent data for a pollutant at facility 4798 (an EPA sampling episode at the same facility as facility 700) met the data editing criteria, then EPA used the effluent data from facility 700 in calculating the long-term averages and limitations for the pollutant. If the influent data for the pollutant at facility 4798 did not meet the criteria, then EPA excluded the data from facility 700.

DEVELOPMENT OF LONG-TERM AVERAGES

10.5

In order to develop the long-term averages and proposed limitations for the centralized waste treatment industry, it was necessary to estimate long-term averages and variability factors. This section discusses the estimation of long-term averages by facility (“facility-specific”) and by option (“pollutant-specific”). For each pollutant of concern (see Chapter 7), EPA calculated long-term averages for each regulatory option and each subcategory. The long-term average represents the average performance level that a facility with well-designed and operated model technologies is capable of achieving.

EPA calculated the long-term average for each pollutant for each facility by arithmetically averaging the pollutant concentrations. The pollutant long-term average for an option was the median of the long-term averages from selected facilities with the technology basis for the option. The following two subsections describe the estimation of the facility-specific and pollutant-specific long-term averages.

Estimation of Facility-Specific***Long-Term Averages******10.5.1***

The facility-specific long-term average for each pollutant for each facility is the arithmetic average of the daily pollutant concentrations of wastewater from the facility. EPA substituted the sample-specific detection limit for each non-detected measurement.

For example, for facility A, if the concentration values for hypothetical pollutant X are:

10 mg/l,

13 mg/l,

non-detect ("ND") with sample-specific detection

limit = 5 mg/l,

12 mg/l, and

15 mg/l

then the facility-specific long-term average is calculated using the sample-specific detection limit of 5 mg/l for the non-detected measurement. This facility-specific long-term average is equal to the average of the five values:

$(10 + 13 + 5 + 12 + 15)/5 \text{ mg/l} = 11 \text{ mg/l}$.

Estimation of Pollutant-Specific***Long-Term Averages******10.5.2***

The pollutant-specific long-term average was the median of the facility-specific long-term averages from the facilities with the model technologies for the option. The median is the midpoint of the values ordered (i.e., ranked) from smallest to largest. If there is an odd number of values (with n =number of values), then the value of the $(n+1)/2$ ordered observation is the median. If there are an even number of values, then the two values of the $n/2$ and $[(n/2)+1]$ ordered observations are arithmetically averaged to obtain the median value.

For example, for subcategory Y option Z, if the four (i.e., $n=4$) facility-specific long-term averages for pollutant X are:

Facility***Long-term average***

A 20 mg/l

B 9 mg/l

C 16 mg/l

D 10 mg/l

then the ordered values are:

Order Facility Long-term average

1 B 9 mg/l

2 D 10 mg/l

3 C 16 mg/l

4 A 20 mg/l

And the pollutant-specific long-term average for option Z is the median of the ordered values (i.e., the average of the 2nd and 3rd ordered values): $(10+16)/2 \text{ mg/l} = 13 \text{ mg/l}$.

The pollutant-specific long-term averages were used in developing the limitations for each pollutant within each proposed option.

Substitutions for***Long-Term Averages******10.5.3******Baseline Values Substituted******for Long-Term Averages******10.5.3.1***

After calculating the pollutant-specific long-term averages for the proposed options, EPA compared these values to the baseline values provided in chapter 15. EPA performed this comparison in response to comments on the 1995 proposal. These comments stated that it was not possible to measure to the low levels required in that proposal. If the long-term average was less than the baseline value, EPA substituted the baseline value for the pollutant-specific long-term average. Table 10-5 identifies the pollutants for options 3 and 4 in the Metals subcategory where this situation occurs. (This situation did not occur for the other subcategories.)

Table 10-5 Metals Subcategory: Long-Term Averages Replaced by the Baseline Values

Option	Pollutant	CAS number	Baseline Value (mg/L)	Long-Term Average (mg/L)
3	beryllium	7440417	5	1
	manganese	7439965	15	12
	silver	7440224	10	5
	tin	7440315	30	28
	titanium	7440326	5	4
	vanadium	7440622	50	11
4	iridium	7439885	1000	500
	vanadium	7440622	50	12

Arsenic Long-Term Average for Metals Subcategory Option 4 10.5.3.2

In developing the limitations for arsenic for option 4 of the metals subcategory, EPA used the long-term average from option 1A. During the EPA sampling episode, the influent concentrations of arsenic were at levels less than EPA's criteria for treatable levels (see explanation of LTA test in section 10.4.3.1). Thus, the data editing criteria excluded the arsenic data from both facilities 4798 and 700. However, the arsenic concentration at facilities in option 1A were at treatable levels. Because the treatment technology in option 4 should provide better removals than option 1A, EPA expects that facilities utilizing the option 4 technologies can achieve arsenic effluent concentration levels at least as low as the values from facilities using the option 1A technologies. Thus, EPA has transferred the long-term average from option 1A to option 4.⁵

⁵Because the data for option 4 provided group variability factors (see section 10.6.7) for the semi-metals group (which includes arsenic), EPA did not transfer develop variability factors using the data from option 1A. Because each group is composed of pollutants with similar chemical structure, EPA expects the variability of the model technology in option 4 to be consistent for all pollutants in the group and thus used the variability factor from option 4.

DEVELOPMENT OF VARIABILITY FACTORS

10.6

In developing the variability factors that were used in calculating the limitations, EPA first developed facility-specific variability factors using the modified delta-lognormal distribution. Second, EPA used these facility-specific variability factors to develop the group-level variability factors. (Chapter 7 describes the assignment of pollutants to groups. Appendix A provides a list of the groups and the associated pollutants.) Third, EPA used the pollutant-specific variability factors to develop the group-level variability factors. For pollutants assigned to groups, EPA then used the group variability factors in calculating the limitations. For pollutants that were not assigned to groups, EPA used the pollutant-specific variability factor.

The following sections describe the modified delta-lognormal distribution and the estimation of the facility-specific, pollutant-specific, and group-level variability factors.

Basic Overview of the Modified Delta-Lognormal Distribution 10.6.1

EPA selected the modified delta-lognormal distribution to model pollutant effluent concentrations from the centralized waste treatment industry in developing the variability

factors. In this industry, wastewater is generated from treating wastes from different sources and industrial processes. A typical effluent data set from a facility in this industry consists of a mixture of measured (detected) and non-detected values. Within a data set, gaps between the values of detected measurements and the sample-specific detection limits associated with non-detected measurements may indicate that different pollutants were present in the different industrial wastes treated by a facility. Non-detected measurements may indicate that the pollutant is not generated by a particular source or industrial process. The modified delta-lognormal distribution is appropriate for such data sets because it models the data as a mixture of measurements that follow a lognormal distribution and non-detect measurements that occur with a certain probability. The model also allows for the possibility that non-detect measurements occur at multiple sample-specific detection limits. Because the data appeared to fit the modified delta-lognormal model reasonably well, EPA believes that this model is the most appropriate model of those evaluated for the centralized waste treatment data.

The modified delta-lognormal distribution is a modification of the 'delta distribution' originally developed by Aitchison and Brown.⁶ The resulting mixed distributional model, that combines a continuous density portion with a discrete-valued spike at zero, is also known as the delta-lognormal distribution. The delta in the name refers to the proportion of the overall distribution contained in the discrete distributional spike at zero, that is, the proportion of zero amounts. The remaining non-zero, non-censored (NC) amounts are grouped together and fit to a lognormal distribution.

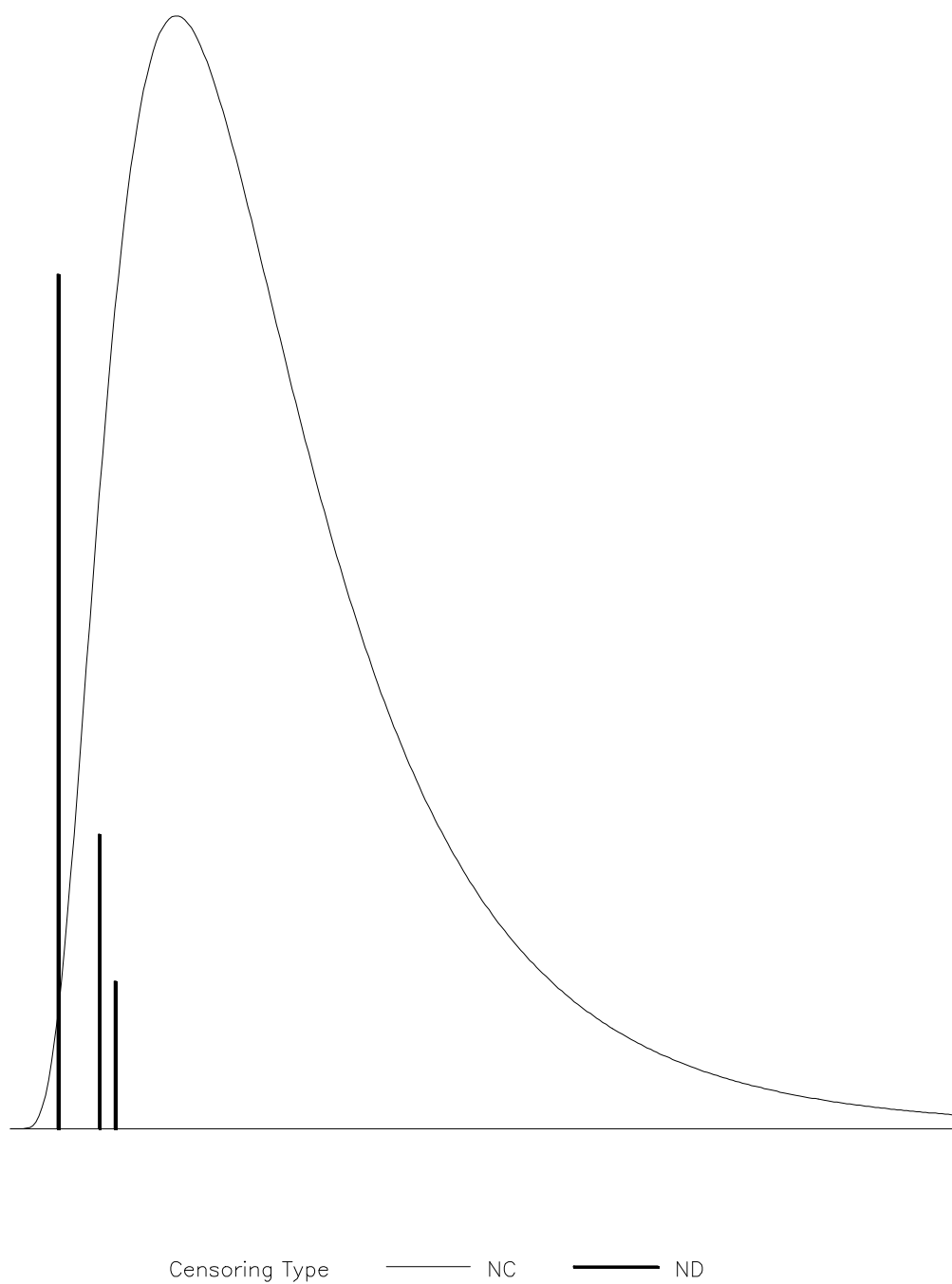
⁶ Aitchison, J. and Brown, J.A.C. (1963) The Lognormal Distribution. Cambridge University Press, pages 87-99.

EPA modified this delta-lognormal distribution to incorporate multiple detection limits. In the modification of the delta portion, the single spike located at zero is replaced by a discrete distribution made up of multiple spikes. Each spike in this modification is associated with a distinct sample-specific detection limit associated with non-detected (ND) measurements in the database.⁷ A lognormal density is used to represent the set of measured values. This modification of the delta-lognormal distribution is shown in Figure 10-1.

The following two subsections describe the delta and lognormal portions of the modified delta-lognormal distribution in further detail.

⁷Previously, EPA had modified the delta-lognormal model to account for non-detected measurements by placing the distributional "spike" at the detection limit (i.e., a single positive value, usually equal to the nominal method detection limit) rather than at zero. For further details, see Kahn and Rubin, 1989. This adaptation was used in developing limitations and standards for the organic chemicals, plastics, and synthetic fibers (OCPSF) and pesticides manufacturing rulemakings. The current modification was used in the pulp and paper and pharmaceutical industry rulemakings.

Figure 10-1
Modified Delta – Lognormal Distribution



Discrete Portion of the Modified Delta-Lognormal Distribution**10.6.2**

In the discrete portion of the modified delta-lognormal distribution, non-detected values were associated with multiple values corresponding to the reported sample-specific detection limits.

Multiple spikes were then constructed and linked to the values of the k distinct sample-specific detection limits observed in the facility data set for the pollutant. In the model, δ represents the proportion of non-detected values and is the sum of smaller fractions, δ_i , each representing the proportion of non-detected values associated with the distinct value of a particular sample-specific detection limit. By letting D_i equal the value of the i^{th} smallest distinct detection limit in the data set and the random variable X_D represent a randomly chosen non-detected measurement, the cumulative distribution function of the discrete portion of the modified delta-lognormal model can be mathematically expressed as:

$$Pr(X_D \leq x) = \sum_{i: D_i \leq x} \delta_i \quad 0 < x \quad (1)$$

$$\hat{E}(X_D) = \frac{1}{\delta} \sum_{i=1}^k \delta_i D_i \quad (2)$$

The mean and variance of this discrete distribution can be calculated using the following formulas:

$$\hat{Var}(X_D) = \frac{1}{\delta^2} \sum_{i=1}^k \sum_{j=i+1}^k \delta_i \delta_j (D_j - D_i)^2 \quad (3)$$

Continuous Portion of the Modified Delta-Lognormal Distribution**10.6.3**

This section describes the lognormal portion of the modified delta-lognormal distribution. The continuous, lognormal portion of the modified delta-lognormal distribution was used to model the detected measurements from the centralized waste treatment industry database.

The cumulative probability distribution of the continuous portion of the modified delta-lognormal distribution can be mathematically expressed as

$$Pr(X_C \leq x) = \Phi [(\log(x) - \mu)/\sigma] \quad (4)$$

where the random variable X_C represents a randomly chosen detected measurement and Φ is the standard normal distribution.

The expected value, $E(X_C)$, and the variance, $Var(X_C)$, of the continuous (lognormal) distribution can be calculated as:

$$E(X_C) = \exp\left(\mu + \frac{\sigma^2}{2}\right) \quad (5)$$

$$\text{Var}(X_C) = \exp(2\mu + \sigma^2) (\exp(\sigma^2) - 1) \quad (6)$$

where

$$\begin{aligned} \mu &= \sum_{i=1}^n \frac{\log(x_i)}{n} \\ \sigma^2 &= \sum_{i=1}^n \frac{[\log(x_i) - \mu]^2}{n-1} \end{aligned} \quad (7)$$

x_i = measured value of the i^{th} detected measurement

n = number of detected values

As shown in the next section, the continuous portion of the modified delta-lognormal distribution combines the discrete and continuous portions to model data sets that contain a mixture of non-detected and detected measurements.

Estimation Under the Modified Delta-Lognormal Distribution

10.6.4

It is possible to fit a wide variety of observed effluent data sets to the modified delta-lognormal distribution. Multiple detection limits for non-detect measurements can be handled, as can measured (“detected”) values. The same basic framework can be used even if there are no non-detected values in the data set. Thus, the modified delta-lognormal distribution offers a large degree of flexibility in modeling effluent data.

The modified delta-lognormal random variable U can be expressed as a combination of three other independent variables, that is,

$$U = I_u X_D + (1 - I_u) X_C \quad (8)$$

where X_D represents a random non-detect from the discrete portion of the distribution, X_C represents a random detected measurement from the continuous lognormal portion, and I_u is an indicator variable signaling whether any particular random measurement is detected or not. Using a weighted sum, the cumulative distribution function from the discrete portion of the distribution (equation 1) can be combined with the function from the continuous portion (equation 4) to obtain the overall cumulative

probability distribution of the modified delta-lognormal distribution as follows,

$$Pr(U \leq u) = \begin{cases} \sum_{i: D_i < u} \delta_i + (1 - \delta) \Phi[(\log(u) - \mu)/\sigma] & \text{if } 0 < u < D_k \\ \delta + (1 - \delta) \Phi[(\log(u) - \mu)/\sigma] & \text{if } u \geq D_k \end{cases} \quad (9)$$

where D_i is the value of the i^{th} sample-specific detection limit with D_k equal to the value of the largest sample-specific detection limit.

The expected value of the random variable U can be derived as a weighted sum of the expected values of the discrete and continuous portions of the distribution (equations 2 and 5, respectively) as follows

$$\hat{E}(U) = \sum_i \delta_i D_i + (1 - \delta) \exp(\hat{\mu} + 0.5 \hat{\sigma}^2) \quad (10)$$

The variance can be obtained by using the following relationship

$$\hat{Var}(U) = \hat{E}(U^2) - [\hat{E}(U)]^2 \quad (11)$$

and using equation 10:

$$\begin{aligned} \hat{Var}(U) = & \frac{1}{\delta^2} \sum_{i=1}^k \sum_{j=i+1}^k \delta_i \delta_j (D_i - D_j)^2 + (1 - \delta) \exp(2\hat{\mu}_{MLE} + \hat{\sigma}^2) (\exp(\hat{\sigma}^2) - 1) \\ & + \delta(1 - \delta) \left[\frac{\sum_{i=1}^k \delta_i D_i}{\delta} - \exp(\hat{\mu} + 0.5 \hat{\sigma}^2) \right]^2 \end{aligned} \quad (12)$$

where D_i equals i^{th} individual sample-specific detection limit for the non-detects, the δ_i are the corresponding proportions of non-detected values associated with D_i , k is the number of unique sample-

specific detection limits, and $\delta = \sum_{i=1}^k \delta_i$.

The next section applies the modified delta-lognormal distribution to the data in estimating facility-specific variability factors for the centralized waste treatment industry. Equations 10 and 12 are particularly important in the estimation of facility-specific variability factors described in the next section.

Estimation of Facility-Specific Variability Factors

10.6.5

This section applies the methodology described in the previous section to the estimation of facility-specific variability factors for each pollutant. EPA estimated the daily variability factors by fitting a modified delta-lognormal distribution to the daily measurements. In contrast, EPA estimated monthly variability factors by fitting a modified delta-lognormal distribution to the monthly averages. These averages were developed using the same number of measurements as the assumed monitoring frequency for the pollutant. EPA is assuming that some pollutants such as organics will be monitored weekly (approximately four times a month) and others will be monitored daily (approximately 20 times a month).⁸ Section 11.5.2 identifies these assumed monitoring frequencies. The following sections describe the facility data set requirements to be used in estimating variability factors, and the estimation of facility-specific daily and monthly variability factors that were used in developing the limitations. These facility-specific variability factors are listed in Attachment 10-3.

Facility Data Set Requirements **10.6.5.1**

Estimates of the necessary parameters for the lognormal portion of the distribution can be calculated with as few as two distinct detected values in a data set (which may also include non-detected measurements). EPA used the facility data set for a pollutant if the data set contained:

- four or more observations with two or more distinct detected concentration values; or

- three detected observations with two or more distinct values.

Further, the each facility data set for a pollutant had to pass the data editing criteria described in section 10.4.3.

In statistical terms, each measurement was assumed to be independently and identically distributed from the other measurements of that pollutant in the facility data set.

Estimation of Facility-Specific

Daily Variability Factors

10.6.5.2

The facility-specific daily variability factor is a function of the expected value, $\hat{E}(U)$, and the 99th percentile of the modified delta-lognormal distribution fit to the daily concentration values of the pollutant in the wastewater from the facility. The expected value, $\hat{E}(U)$, was estimated using equation 10.

The 99th percentile of the modified delta-lognormal distribution fit to each data set was estimated by using an iterative approach. First, $D_0=0$, $\delta_0=0$, and $D_{k+1} = \infty$ were defined as boundary conditions where D_i equaled the i^{th} smallest detection limit and δ_i was the associated proportion of non-detects at the i^{th} detection limit. Next, a cumulative distribution function, p , for each data subset was computed as a step function ranging from 0 to 1. The general form, for a given value c , was:

⁸Compliance with the monthly average limitations will be required in the final rulemaking regardless of the number of samples analyzed and averaged.

$$p = \sum_{i=0}^m \delta_i + (1 - \delta) \Phi \left[\frac{\log(c) - \hat{\mu}}{\hat{\sigma}} \right], \quad D_m \leq c < D_{m+1}, \quad m=0,1,\dots,k. \quad (13)$$

where Φ is the standard normal cumulative distribution function. The following steps were completed to compute the estimated 99th percentile of each data subset:

Step 1 Using equation 13, k values of p at $c=D_m$, $m=1,\dots,k$ were computed and labeled p_m .

Step 2 The smallest value of m ($m=1,\dots,k$), such that $p_m \geq 0.99$, was determined and labeled as p_j . If no such m existed, steps 3 and 4 were skipped and step 5 was computed instead.

Step 3 Computed $p^* = p_j - \delta_j$.

Step 4 If $p^* < 0.99$, then $P99 = D_j$
 else if $p^* \geq 0.99$, then

$$\hat{P}99 = \exp \left[\hat{\mu} + \Phi^{-1} \left[\frac{0.99 - \sum_{i=0}^{j-1} \delta_i}{(1 - \delta)} \right] \hat{\sigma} \right] \quad (14)$$

where Φ^{-1} is the inverse normal distribution function.

Step 5 If no such m exists such that $p_m \geq 0.99$ ($m=1,\dots,k$), then

$$\hat{P}99 = \exp \left[\hat{\mu} + \Phi^{-1} \left[\frac{0.99 - \delta}{(1 - \delta)} \right] \hat{\sigma} \right] \quad (15)$$

The facility-specific daily variability factor, VF1, was then calculated as:

$$VF1 = \frac{\hat{P}99}{\hat{E}(U)} \quad (16)$$

Estimation of Facility-Specific Monthly Variability Factors

10.6.5.3

EPA estimated the monthly variability factors by fitting a modified delta-lognormal distribution to the monthly averages. EPA developed these averages using the same number of measurements as the assumed monitoring frequency for the pollutant. EPA is assuming that some pollutants such as organics will be monitored weekly (approximately four times a month) and others will be monitored daily

(approximately 20 times a month).⁹ Section 11.5.2 identifies these assumed monitoring frequencies.

ESTIMATION OF FACILITY-SPECIFIC 4-DAY VARIABILITY FACTORS

Variability factors based on 4-day monthly averages were estimated for pollutants with the monitoring frequency assumed to be weekly (approximately four times a month). In order to calculate the 4-day variability factors (VF₄), the assumption was made that the approximating distribution of \bar{U}_4 , the sample mean for a random sample of four independent concentrations, was also derived from the modified delta-lognormal distribution.¹⁰ To obtain the expected value of the 4-day averages, equation 10 is modified for the mean of the distribution of 4-day averages in equation 17:

$$\hat{E}(\bar{U}_4) = \delta_4 \hat{E}(\bar{X}_4)_D + (1 - \delta_4) \hat{E}(\bar{X}_4)_C \quad (17)$$

where $(\bar{X}_4)_D$ denotes the mean of the discrete portion of the distribution of the average of four independent concentrations, (i.e., when all observations are non-detected values) and $(\bar{X}_4)_C$ denotes the mean of the continuous lognormal portion (i.e., when all observations are detected).

First, it was assumed that the probability of detection (δ) on each of the four days was independent of the measurements on the other three days. (As explained in section 10.6.5.1, daily measurements were also assumed to be independent.) Thus, $\delta_4 = \delta^4$ and because $\hat{E}(\bar{X}_4)_D = \hat{E}(X_D)$, then equation 17 can be expressed as

$$\hat{E}(\bar{U}_4) = \delta^4 \sum_{i=1}^k \frac{\delta_i D_i}{\delta} + (1 - \delta^4) \exp(\hat{\mu}_4 + 0.5 \hat{\sigma}_4^2) \quad (18)$$

where k is the number of distinct non-detected values. Solving for $\hat{\mu}_4$ using equation 18 and because $\hat{E}(\bar{U}_4) = \hat{E}(U)$:

$$\hat{\mu}_4 = \log \left[\frac{\hat{E}(U) - \delta^3 \sum_{i=1}^k \delta_i D_i}{(1 - \delta^4)} \right] - 0.5 \hat{\sigma}_4^2 \quad (19)$$

The expression for $\hat{\sigma}_4^2$ was derived from the following relationship

⁹The attachments to this chapter (except Attachment 10-5 which provides the proposed limitations) sometimes identify two monthly variability factors and monthly average limitations for a single pollutant in an option. These two sets of variability factors and limitations correspond to monitoring four and twenty times a month. In developing the limitations, EPA considered both monitoring frequencies. However, EPA is proposing only the monitoring frequencies identified in section 11.5.2.

¹⁰This assumption appeared to be reasonable for the pulp and paper industry data that had percentages of non-detected and detected measurements similar to the data sets for the centralized waste treatment industry. This conclusion was based on the results of a simulation of 7,000 4-day averages. A description of this simulation and the results are provided in the record for the proposed rulemaking.

$$\begin{aligned}\hat{Var}(\bar{U}_4) &= \delta_4 \hat{Var}((\bar{X}_4)_D) + (1 - \delta_4) \hat{Var}((\bar{X}_4)_C) \\ &+ \delta_4(1 - \delta_4)[\hat{E}(\bar{X}_4)_D - \hat{E}(\bar{X}_4)_C]^2\end{aligned}\quad (20)$$

by substituting the following

$$\hat{Var}((\bar{X}_4)_D) = \frac{\hat{Var}(X_D)}{4}, \quad \hat{E}(\bar{X}_4)_D = \hat{E}(X_D), \quad \text{and} \quad \delta_4 = \delta^4 \quad (21)$$

into equation 20. This substitution provides the following

$$\hat{Var}(\bar{U}_4) = \delta^4 \frac{\hat{Var}(X_D)}{4} + (1 - \delta^4) \hat{Var}((\bar{X}_4)_C) + \delta^4(1 - \delta^4)[\hat{E}(\bar{X}_D) - \hat{E}(\bar{X}_4)_C]^2 \quad (22)$$

which further simplifies to

$$\begin{aligned}\hat{Var}(\bar{U}_4) &= \frac{\delta^4 \sum_{i=1}^k \sum_{j=1}^k \delta_i \delta_j (D_i - D_j)^2}{4\delta^2} + (1 - \delta^4) \exp(2\hat{\mu}_4 + \hat{\sigma}_4^2) [\exp(\hat{\sigma}_4^2) - 1] \\ &+ \delta^4(1 - \delta^4) \left[\sum_{i=1}^k \frac{\delta_i D_i}{\delta} - \exp(\hat{\mu}_4 - 0.5\hat{\sigma}_4^2) \right]^2\end{aligned}\quad (23)$$

Next, equation 24 results from solving for $[\exp(\hat{\sigma}_4^2) - 1]$ in equation 23.

$$\exp(\hat{\sigma}_4^2) - 1 =$$

$$\frac{\left[\hat{Var}(\bar{U}_4) - \frac{\delta^2 \sum_{i=1}^k \sum_{j=1}^k \delta_i \delta_j (D_i - D_j)^2}{4} - \delta^2(1 - \delta^4) \left[\sum_{i=1}^k \delta_i D_i - \delta \exp(\hat{\mu}_4 - 0.5\hat{\sigma}_4^2) \right]^2 \right]}{(1 - \delta^4) \exp(2\hat{\mu}_4 + \hat{\sigma}_4^2)} \quad (24)$$

Then solving for $\exp(\hat{\mu}_4 + 0.5\hat{\sigma}_4^2)$ using equation 18 and substituting $\hat{E}(\bar{U}_4) = \hat{E}(U)$ results in

$$\exp(\hat{\mu}_4 + 0.5\hat{\sigma}_4^2) = \frac{[\hat{E}(\bar{U}_4) - \delta^3 \sum_{i=1}^k \delta_i D_i]}{(1 - \delta^4)} = \frac{[\hat{E}(U) - \delta^3 \sum_{i=1}^k \delta_i D_i]}{(1 - \delta^4)} \quad (25)$$

Letting

$$\eta = \hat{E}(U) - \delta^3 \sum_{i=1}^k \delta_i D_i \quad (26)$$

simplifies equation 25 to

$$\exp(\hat{\mu}_4 + 0.5\hat{\sigma}_4^2) = \frac{\eta}{(1 - \delta^4)} \quad (27)$$

Next, solving for $\hat{\sigma}_4^2$ in equation 24 and using the substitution in equation 27 provides

$$\hat{\sigma}_4^2 = \log \left[1 + \frac{\left[\hat{Var}(\bar{U}_4) - \frac{\delta^2 \sum_{i=1}^k \sum_{j=1}^k \delta_i \delta_j (D_i - D_j)^2}{4} - \delta^2 (1 - \delta^4) \left(\sum_{i=1}^k \delta_i D_i - \frac{\delta \eta}{(1 - \delta^4)} \right)^2 \right]}{\frac{(1 - \delta^4) \eta^2}{(1 - \delta^4)^2}} \right] \quad (28)$$

Finally, using the relationship $\hat{Var}(\bar{U}_4) = \hat{Var}(U)/4$ and rearranging terms:

$$\hat{\sigma}_4^2 = \log \left[1 + \frac{(1 - \delta^4) \hat{Var}(U)}{4\eta^2} - \frac{(1 - \delta^4) \delta^2 \sum_{i=1}^k \sum_{j=1}^k \delta_i \delta_j (D_i - D_j)^2}{4\eta^2} - \frac{\delta^2 \left[\sum_{i=1}^k \delta_i D_i (1 - \delta^4) - \delta \eta \right]^2}{\eta^2} \right] \quad (29)$$

Thus, estimates of $\hat{\mu}_4$ and $\hat{\sigma}_4^2$ in equations 19 and 29, respectively, were derived by using estimates of $\delta_1, \dots, \delta_k$ (sample proportion of non-detects at observed sample-specific detection limits D_1, \dots, D_k), $\hat{E}(U)$ from equation 10, and $\hat{Var}(U)$ from equation 12.

In finding the estimated 95th percentile of the average of four observations, four non-detects, not all at the same sample-specific detection limit, can generate an average that is not necessarily equal to D_1 , D_2, \dots , or D_k . Consequently, more than k discrete points exist in the distribution of the 4-day averages. For example, the average of four non-detects at $k=2$ detection limits, are at the following discrete points with the associated probabilities:

i	D_i^*	δ_i^*
1	D_1	δ_1^4
2	$(3D_1 + D_2)/4$	$4\delta_1^3\delta_2$
3	$(2D_1 + 2D_2)/4$	$6\delta_1^2\delta_2^2$
4	$(D_1 + 3D_2)/4$	$4\delta_1\delta_2^3$
5	D_2	δ_2^4

When all four observations are non-detected values, and when k distinct non-detected values exist, the multinomial distribution can be used to determine associated probabilities. That is,

$$Pr \left[\bar{U}_4 = \frac{\sum_{i=1}^k u_i D_i}{4} \right] = \frac{4!}{u_1! u_2! \dots u_k!} \prod_{i=1}^k \delta_i^{u_i} \quad (30)$$

where u_i is the number of non-detected measurements in the data set with the D_i detection limit. The number of possible discrete points, k^* , for $k=1,2,3,4$, and 5 are as follows:

k	k^*
1	1
2	5
3	15
4	35
5	70

To find the estimated 95th percentile of the distribution of the average of four observations, the same basic steps (described in section 10.6.5.2) as for the 99th percentile of the distribution of daily observations, were used with the following changes:

- Step 1 Change P_{99} to P_{95} , and 0.99 to 0.95.
- Step 2 Change D_m to D_m^* , the weighted averages of the sample-specific detection limits.
- Step 3 Change δ_i to δ_i^* .
- Step 4 Change k to k^* , the number of possible discrete points based on k detection limits.
- Step 5 Change the estimates of δ , $\hat{\mu}$, and $\hat{\sigma}$ to estimates of δ^4 , $\hat{\mu}_4$, and $\hat{\sigma}_4^2$, respectively.

Then, using $\hat{E}(\bar{U}_4) = \hat{E}(U)$, the estimate of the facility-specific 4-day variability factor, VF4, was calculated as:

$$VF4 = \frac{\hat{P}_{95}}{\hat{E}(U)} \quad (31)$$

AUTOCORRELATION IN THE DAILY MEASUREMENTS

Before estimating the facility-specific 20-day variability factors, EPA considered whether autocorrelation was likely to be present in the effluent data. When data are said to be positively autocorrelated, it means that measurements taken at consecutive time periods are related. For example, positive autocorrelation would be present in the data if the final effluent concentration of oil and grease was relatively high one day and was likely to remain at similar high values the next and possibly succeeding days. Because EPA is assuming that some pollutants (BOD₅, TSS, oil and grease, metals, and total cyanide) will be monitored daily, EPA based the 20-day variability factors on the distribution of the averages of 20 measurements.¹¹ If concentrations measured on consecutive days were positively correlated, then the autocorrelation would have had an effect on the estimate of the variance of the monthly average and thus on the 20-day variability factor. (The estimate of the long-term average and the daily variability factor would not be affected by autocorrelation.)

EPA believes that autocorrelation in any significant amount is unlikely to be present in daily measurements in wastewater from this industry. Thus, EPA has not incorporated autocorrelation into its estimates of the 20-day variability factors. In many industries, measurements in final effluent are likely to be similar from one day to the next because of the consistency from day-to-day in the production processes and in final effluent discharges due to

the hydraulic retention time of wastewater in basins, holding ponds, and other components of wastewater treatment systems. Unlike these other industries, where the industrial processes are expected to produce the same type of wastewater from one day to the next, the wastewater from centralized waste treatment industry is generated by treating wastes from different sources and industrial processes. The wastes treated on a given day will often be different than the waste treated on the following day. Because of this, autocorrelation would be expected to be absent from measurements of wastewater from the centralized waste treatment industry.

EPA believes that a statistical evaluation of appropriate data sets would likely support its assertion that autocorrelation is absent from daily measurements in the centralized waste treatment industry. However, the monitoring data that EPA has received thus far are insufficient for the purpose of evaluating the autocorrelation.¹² To determine autocorrelation in the data, many measurements for each pollutant would be required with values for every single day over an extended period of time. Such data were not available to EPA. In the preamble to the proposal, EPA requests additional data that can be used to evaluate autocorrelation in the data.

¹¹In other rulemakings, EPA has used the averages of 30 measurements when the assumed monitoring frequency was daily measurements throughout the month. However, many centralized waste treatment facilities are closed on weekends. Therefore, EPA assumed that 20 daily measurements rather than 30 would be collected each month.

¹²In the 1995 statistical support document, EPA included a discussion of the autocorrelation in the effluent data from facility 602. The document states that the facility provided 'sufficient amounts of pollutant measurements.' That statement is not correct. To have sufficient amounts of data, the data set would need to include many more measurements for every single day. In addition, in the 1995 document, the conclusions about statistical significance were flawed due to an error in the software.

ESTIMATION OF FACILITY-SPECIFIC 20-DAY VARIABILITY FACTORS

Based upon the discussion on autocorrelation in the previous section, it was assumed that consecutive daily measurements were independent of one another, and therefore

$$\hat{E}(\bar{U}_{20}) = \hat{E}(U) \quad \text{and} \quad \hat{Var}(\bar{U}_{20}) = \frac{\hat{Var}(U)}{20} \quad (32)$$

where $\hat{E}(U)$ and $\hat{Var}(U)$ were calculated as shown in section 10.6.5.3.2 (see equations 10 and 12). Finally, since \bar{U}_{20} is approximately normally distributed by the Central Limit Theorem, the estimate of the 95th percentile of a 20-day mean and the corresponding facility-specific 20-day variability factor (VF20) were approximated by

$$\hat{P}95_{20} = \hat{E}(\bar{U}_{20}) + [\Phi^{-1}(0.95)]\sqrt{\hat{Var}(\bar{U}_{20})} \quad (33)$$

By using the substitutions in equation 32, equation 33 simplified to

$$\hat{P}95_{20} = \hat{E}(U) + [\Phi^{-1}(0.95)]\sqrt{\frac{1}{20}\hat{Var}(U)} \quad (34)$$

Then, the estimate of the facility-specific 20-day variability factor, VF20, was calculated using:

$$VF20 = \frac{\hat{P}95}{\hat{E}(U)} \quad \text{because} \quad \hat{E}(\bar{U}_{20}) = \hat{E}(U) \quad (35)$$

where $\Phi^{-1}(0.95)$ is the 95th percentile of the inverse normal distribution.

Evaluation of Facility-Specific Variability Factors

10.6.5.4

Estimates of the necessary parameters for the lognormal portion of the distribution can be calculated with as few as two distinct measured values in a data set (which may also include non-detected measurements); however, these estimates are likely to be unstable unless a more sizable number of measured values is available. As stated in section 10.6.5.1, EPA used the modified delta-lognormal distribution to develop facility-specific variability factors for data sets that had a four or more observations with two or more distinct measured concentration values or three measured values with two or more distinct values. Some variance estimates produced unexpected results such as a daily variability

factor with a value less than 1.0 which would result in a limitation with a value less than the long-term average. This was an indication that the estimate of $\hat{\sigma}$ (the log standard deviation) was unstable. To identify situations producing unexpected results, EPA carefully reviewed all of the variability factors and compared daily to monthly variability factors. EPA determined that when the facility's daily variability factor was less than 1.0, the daily and monthly variability factors for that pollutant should be excluded from further consideration. Similarly, when the facility's monthly variability factors for a pollutant were greater than the daily variability factor, EPA excluded the daily and monthly variability factors from further consideration. If the daily variability factor was greater than 10.5,

EPA reviewed the data in detail to determine if one or more values were the result of process upsets or data errors.

Estimation of Pollutant-Specific Variability Factors

10.6.6

After the facility-specific variability factors were estimated for a pollutant as described in section 10.6.5, the pollutant-specific variability factor was calculated. The pollutant-specific daily variability factor was the mean of the facility-specific daily variability factors for that pollutant in the subcategory and option. Likewise, the pollutant-specific monthly variability factor was the mean of the facility-specific monthly variability factors for that pollutant in the subcategory and option. For example, for option 4 of the Metals subcategory, the cadmium daily variability factor was the mean of the cadmium daily variability factors from facilities 4798 and facility 700. A more detailed example of estimating pollutant-specific monthly variability factors is provided in section 10.7.2. Attachment 10-2¹³ lists the pollutant-specific variability factors.

Estimation of Group-Level Variability Factors

10.6.7

After the pollutant-specific variability factors were estimated as described in section 10.6.6, the

group-level variability factors were calculated. Each group contained pollutants that had similar chemical structure (e.g., the metals group consisted of metal pollutants). For some pollutants such as BOD₅, EPA determined that there were no other pollutants that could be considered chemically similar for the purpose of determining variability factors; therefore, these pollutants were not assigned to a group.¹⁴ For the pollutants (such as BOD₅) that were not assigned to a group, the pollutant-specific variability factors were used in developing limitations. However, in most cases, group-level variability factors were used in developing limitations. (The derivation of limitations is described in section 10.7.1.) Appendix A identifies the groups and the pollutants assigned to them.

The group-level daily variability factor was the median of the pollutant-specific daily variability factors for the pollutants within the group. Similarly for the monthly variability factors, the group-level monthly variability factor was the median of the pollutant-specific monthly variability factors for the pollutants within the group. Attachment 10-4 provides the group-level daily and monthly variability factors that could be calculated for the proposed options.

Transfers of Variability Factors

10.6.8

In some cases, EPA transferred variability factors for pollutants when its associated group-level variability factors could not be estimated. In these cases, the facility data sets for that pollutant and the other pollutants in the group were excluded (section 10.4.1), did not meet the data editing criteria (section 10.4.3), did not meet the facility data set requirements (section 10.6.5.1), or the facility-specific variability factors were excluded (section 10.6.5.4).

¹³Attachments 10-2 through 10-7 include some pollutants for which EPA has not proposed limitations. In some cases, the data from these additional pollutants were used to develop the group variability factors (see section 10.6.7). For other pollutants, at some point in developing the proposal, EPA considered proposing limitations; however, EPA later excluded them from the proposed limitations (see chapter 7 for further explanation). These attachments reflect the calculations prior to transfers of limitations as described in section 10.8. In addition, a revision to the TSS limitations for oils subcategory option 9 is not incorporated into these attachments.

¹⁴In some data listings, such cases are sometimes identified with a group; however, the group name and the pollutant name are the same.

EPA transferred variability factors for these cases using other group-level variability factors in the option for the subcategory.¹⁵ In developing these transferred variability factors, EPA calculated the transferred variability factors as the median (i.e., mid-point value) of the group-level variability factors from all groups except the metals, semi-metals, and non-metals groups. For example, for hypothetical subcategory X, suppose its option 2 had five groups: TSS, oil and grease, n-paraffins, aromatics, and metals. In addition, suppose that group-level variability factors had been calculated for all groups except n-paraffins, then the transferred daily variability factor for the pollutants in the n-paraffins group would be the median of the group-level daily variability factors from the TSS, oil and grease, and aromatics group. (The daily variability factor from the metals group would be excluded.) The transferred monthly (4-day) variability factor would be the 4-day variability factor from the aromatics group, because 4-day variability factors were not calculated for TSS and oil and grease (because the monitoring frequency was assumed to be 20 times per month.)

¹⁵In the 1995 proposal, EPA proposed using fraction-level variability factors when group-level variability factors were unavailable. EPA has determined that more appropriate transfers are available.

Table 10-6 Cases where Variability Factors were Transferred

Subcategory	Option	Pollutant	Transferred Variability Factors		Monitoring Frequency (days per month)
			Daily	Monthly	
Metals	4	Hexavalent chromium	3.348	1.235	20
Oils	8/8v	alpha-terpineol	2.907	1.467	4
		carbazole			
	9/9v	alpha-terpineol	3.434	1.682	4
		carbazole			
Organics	3/4	acetophenone	4.330	1.992	4
		aniline			
		benzoic acid			
		2,3-dichloroaniline			

LIMITATIONS***10.7***

The proposed limitations and standards are the result of multiplying the long-term averages by the appropriate variability factors. The same basic procedures apply to the calculation of all limitations and standards for this industry, regardless of whether the technology is BPT, BCT, BAT, NSPS, PSES or PSNS.

The proposed limitations for pollutants for each option are provided as ‘daily maximums’ and ‘maximums for monthly averages.’ Definitions provided in 40 CFR 122.2 state that the daily maximum limitation is the “highest allowable ‘daily discharge’” and the maximum for monthly average limitation (also referred to as the “monthly average limitation”) is the “highest allowable average of ‘daily discharges’ over a calendar month, calculated as the sum of all ‘daily discharges’ measured during a calendar month divided by the number of ‘daily discharges’ measured during that month.” Daily discharges are defined to be the “‘discharge of a pollutant’ measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of samplings.”

EPA calculates the limitations based upon percentiles chosen with the intention, on one hand, to be high enough to accommodate reasonably anticipated variability within control of the facility and, on the other hand, to be low

enough to reflect a level of performance consistent with the Clean Water Act requirement that these effluent limitations be based on the “best” technologies. The daily maximum limitation is an estimate of the 99th percentile of the distribution of the daily measurements. The monthly average limitation is an estimate of the 95th percentile of the distribution of the monthly averages of the daily measurements. EPA used the 95th percentile rather than the 99th percentile for monthly average limitations because the variability of monthly averages is less than the variability of individual daily measurements. The percentiles for both types of limitations are estimated using the products of long-term averages and variability factors.

In the first of two steps in estimating both types of limitations, EPA determines an average performance level (the “long-term average” discussed in section 10.7) that a facility with well-designed and operated model technologies (which reflect the appropriate level of control) is capable of achieving. This long-term average is calculated from the data from the facilities using the model technologies for the option. EPA expects that all facilities subject to the limitations will design and operate their treatment systems to achieve the long-term average performance level on a consistent basis because facilities with well-designed and operated model technologies have demonstrated that this can be done.

In the second step of developing a limitation, EPA determines an allowance for the variation in pollutant concentrations when processed through extensive and well designed treatment systems. This allowance for variance incorporates all components of variability including shipping, sampling, storage, and analytical variability. This allowance is incorporated into the limitations through the use of the variability factors (discussed in section 10.6) which are calculated from the data from the facilities using the model technologies. If a facility operates its treatment system to meet the relevant long-term average, EPA expects the facility to be able to meet the limitations. Variability factors assure that normal fluctuations in a facility's treatment are accounted for in the limitations. By accounting for these reasonable excursions above the long-term average, EPA's use of variability factors results in limitations that are generally well above the actual long-term averages.

After completing the data screening tests to select the appropriate data sets, EPA calculated the long-term averages for the limitations. For some pollutants of concern, none of the facility data sets with the technology basis for the option met the data screening criteria; thus, these pollutants of concern are not proposed to be regulated for that option. These pollutants are listed in Chapter 7, Table 7-1. Further, because of these criteria, the options within a subcategory may have slightly different lists of pollutants proposed to be regulated. These data were used to develop long-term averages and variability factors, by pollutant and technology option, for each subcategory. The limitations prior to transfers are listed in Attachment 10-7.

Steps Used to Derive Limitations **10.7.1**

This section summarizes the steps used to derive the limitations. These steps were used separately for the daily maximum limitation and

the monthly average limitation. Depending on the assumed monitoring frequency of the pollutant, either the 4-day variability factor or the 20-day variability factor was used in deriving the monthly average limitation.

Step 1 EPA calculated the facility-specific long-term averages and variability factors for all facilities that had the model technology for the option in the subcategory. EPA calculated variability when the facility had four or more observations with two or more distinct detected values or three detected values with two or distinct values. In addition, the facility data set for the pollutant had to meet the data screening criteria.

Step 2 For each option in the subcategory, EPA calculated the median of the facility-specific long-term averages and the mean of the facility-specific variability factors from the facilities with the model technology to provide the pollutant-specific long-term average and variability factors for each pollutant.

Step 3 EPA calculated the group-level variability factor using the median of the pollutant-specific variability factors for the pollutants within each group.

Step 4 In most cases, EPA calculated the limitation for a pollutant using the product of the pollutant-specific long-term average and the group-level variability factor. If the group-level variability factor could not be estimated (because none of the pollutant-specific variability factors in the group could be estimated), then EPA transferred variability factors (see section 10.6.8)

and the used pollutant-specific long-term average in calculating the limitation. If the pollutant was not assigned to a group, then EPA calculated the limitation using the product of the pollutant-specific long-term average and the pollutant-specific variability factors. (See exceptions to step 4 described in section 10.8.2.)

Example

10.7.2

This example illustrates the derivation of limitations using the steps described above. In this example, four pollutants, A, B, C, and D all belong to hypothetical group X. The facility-specific long-term averages and variability factors for the pollutants are shown in Attachments 10-1 and 10-3, respectively (step 1). Table 10-7 shows the pollutant-specific long-term averages and variability factors calculated as described in step 2. Then, using the procedure in step 3, the group-level variability factor (see attachment 10-4 in Appendix E) is the median of the variability factors for pollutants A, B, and C (D is excluded because facility-specific variability factors could not be calculated for any of the facilities that provided data on pollutant D).

- The group-level daily variability factor for group X is 2.2 which is the median of 2.2 (pollutant A), 2.4 (pollutant B), and 2.1 (pollutant C).
- The group-level 4-day variability factor for group X is 1.4 which is the median of 1.5 (pollutant A), 1.4 (pollutant B), and 1.2 (pollutant C).

In this example, the limitations are calculated using the pollutant-specific long-term averages and the group-level variability factors in the following way:

Daily maximum limitation

= pollutant-specific long-term average
* group-level daily variability factor

For each pollutant, the daily maximum limitation is:

Pollutant A: $15 \text{ mg/l} * 2.2 = 33 \text{ mg/l}$

Pollutant B: $14 \text{ mg/l} * 2.2 = 31 \text{ mg/l}$

Pollutant C: $22 \text{ mg/l} * 2.2 = 48 \text{ mg/l}$

Pollutant D: $20 \text{ mg/l} * 2.2 = 44 \text{ mg/l}$

Monthly average limitation

= pollutant-specific long-term average
* group-level 4-day variability factor

For each pollutant, the monthly average limitation is:

Pollutant A: $15 \text{ mg/l} * 1.4 = 21 \text{ mg/l}$

Pollutant B: $14 \text{ mg/l} * 1.4 = 20 \text{ mg/l}$

Pollutant C: $22 \text{ mg/l} * 1.4 = 31 \text{ mg/l}$

Pollutant D: $20 \text{ mg/l} * 1.4 = 28 \text{ mg/l}$

Table 10-7. Long-Term Averages and Variability Factors Corresponding to Example for Hypothetical Group X

Pollutant	Facility	Long-term Average (mg/l)	Daily Variability Factor	4-day Variability Factor
A	A1	10	2.1	1.4
	A2	12	2.3	1.5
	A3	15	2.0	1.4
	A4	20	1.8	1.3
	A5	26	2.8	1.9
	Pollutant-specific	15 (median)	2.2 (mean)	1.5 (mean)
B	B1	17	2.7	1.7
	B2	16	2.2	1.2
	B3	10	2.3	1.3
	B4	12	*	*
	Pollutant-specific	14 (median)	2.4 (mean)	1.4 (mean)
C	C1	22	1.9	1.1
	C2	24	*	*
	C3	12	2.3	1.3
	Pollutant-specific	22 (median)	2.1 (mean)	1.2 (mean)
D	D1	20	*	*
	D2	22	*	*
	D3	14	*	*
	Pollutant-specific	20 (median)	*	*

* could not be estimated (i.e., the data set did not contain four or more observations with two or more distinct detected values or three detected values with two or more distinct values.)

TRANSFERS OF LIMITATIONS

10.8

limitations were transferred.

In some cases, EPA was either unable to calculate a limitation using the available data for an option or determined that the treatment provided by facilities employing the option did not represent BPT/BCT/BAT treatment. In these cases, EPA transferred limitations from another option or from another industrial category. The following sections describe each case where the

Transfer of Oil and Grease Limitation for Metals Subcategory Option 4 to Option 3

10.8.1

Because of the relatively low levels of oil and grease in the influent of the facilities with the model technology for Metals subcategory option 3, application of the LTA test to the influent data

(described in section 10.4.3.1) resulted in excluding the effluent data. EPA believes that this parameter should be regulated for all options in this subcategory. EPA based the oil and grease limitations upon data from facilities with the option 4 model technology. In effect, EPA has transferred the limitations from option 4 to option 3 for oil and grease. EPA has concluded that transfer of this data is appropriate given that the technology basis for metals option 3 includes additional treatment steps than the technology basis for metals option 4. As such, EPA has every reason to believe that facilities employing the option 3 technology could achieve the limitations based on the option 4 technology.

Transfers of Limitations from Other Rulemakings to CWT Industry 10.8.2

In some cases, the model technology did not optimally remove BOD₅ and TSS for an option in a subcategory. EPA believes this occurred because the limitations are largely based on indirect discharging facilities that are not required to control or optimize their treatment systems for the removal of conventional parameters. Thus, EPA transferred the BPT/BCT limitations (for direct dischargers data) from effluent guidelines from other industries with similar wastewaters and treatment technologies. In one case, EPA proposes the transfer of the BPT/BCT TSS limitations from the Metal Finishing rulemaking to the Metals subcategory BPT/BCT limitations (option 4). In the other case, EPA proposes the transfer of the BPT/BCT BOD₅ and TSS limitations from the Organic Chemical, Plastics, and Synthetic Fibers (OCPSF) rulemaking to the Organics subcategory BPT/BCT limitations (option 3/4). EPA used different procedures from the one discussed in section 10.7.1 to develop the proposed limitations for BOD₅ and TSS for the organics subcategory and TSS for option 4 in the Metals subcategory. The following sections describe these different

procedures.

Transfer of BOD₅ and TSS for the Organics Subcategory 10.8.2.1

EPA based the transferred limitations of BOD₅ and TSS for the organics subcategory on biological treatment performance data used to develop the limitations for the thermosetting resins subcategory in the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) industry rulemaking. As described in the preamble to the proposed rulemaking, EPA determined that the transfer of the data was warranted because facilities in the organics subcategory treat wastes similar to wastes treated by OCPSF facilities.

For the organics subcategory of the centralized waste treatment industry, the proposed daily maximum limitations for BOD₅ and TSS were transferred directly from the OCPSF rulemaking. No modifications were required before transferring these daily maximum limitations.

Some modifications of the OCPSF monthly average limitations were required before the values could be transferred to the centralized waste treatment industry. The OCPSF limitations for BOD₅ and TSS were based on assumptions of a monitoring frequency of 30 days and the presence of autocorrelation in the measurements. In the proposed rulemaking for the centralized waste treatment industry, the monthly limitations for BOD₅ and TSS were based on an assumed monitoring frequency of 20 days and no autocorrelation (see section 10.6.5.3.2 for a discussion of the absence of autocorrelation in the centralized waste treatment data). Therefore, the following conversion steps were necessary to convert the OCPSF 30-day variability factors to 20-day variability factors.

The following formula was used in the OCPSF rulemaking to calculate the 30-day variability factors. This formula incorporates autocorrelation between measurements on adjacent days (i.e., the lag-1 autocorrelation).

$$VF_{30} = 1 + 1.645 \sqrt{\frac{(e^{\sigma^2} - 1)f_{30}(\rho, \sigma)}{30}} \quad (36)$$

where the function $f_{30}(\rho, \sigma)$ represents the additional variability attributable to autocorrelation, and is given by

$$f_{30}(\rho, \sigma) = 1 + \frac{2}{30(e^{\sigma^2} - 1)} \sum_{k=1}^{29} (30-k)(e^{\rho^k \sigma^2} - 1) \quad (37)$$

The above two formulas can be generalized to estimate n-day variability factors. These formulas are:

$$VF_n = 1 + 1.645 \sqrt{\frac{(e^{\sigma^2} - 1)f_n(\rho, \sigma)}{n}} \quad n \geq 2 \quad (38)$$

where

$$f_n(\rho, \sigma) = 1 + \frac{2}{n(e^{\sigma^2} - 1)} \sum_{k=1}^{n-1} (n-k)(e^{\rho^k \sigma^2} - 1) \quad n \geq 2 \quad (39)$$

For the proposed limitations, the autocorrelation, ρ , has been assumed to be absent; thus, the value of ρ is set equal to zero. Therefore, the value of $f_n(0, \sigma)$ is equal to 1, and equation 38 becomes:

$$VF_n = 1 + 1.645 \sqrt{\frac{(e^{\sigma^2} - 1)}{n}} \quad n \geq 2 \quad (40)$$

Because all of the values were detected (i.e., there were no non-detected measurements) in the OCPSF data base for BOD₅ and TSS, the delta-lognormal distribution of these data is the same as the lognormal distribution (i.e., the delta portion does not apply because it is used to model non-detect measurements). Therefore, an estimate of σ^2 was obtained from the daily variability factor from the lognormal distribution by using the following equation:

$$VF_1 = e^{\sigma \Phi^{-1}(0.99) - \frac{\sigma^2}{2}} \quad (41)$$

where $\Phi^{-1}(0.99)$ is the 99th percentile of the inverse normal distribution. (The value of $\Phi^{-1}(0.99)$ is 2.326.) By solving this equation using maximum likelihood estimation for σ and substituting it into

equation 40, an estimate of VF_n may be obtained. Finally, the n-day limitation is given by:

$$Limit_n = \frac{VF_n}{E(X)} \quad (42)$$

The expected value, $E(X)$ can be estimated by solving for $E(X)$ in the following equation for the daily maximum limitation (which is the same for both the OCPSF, and centralized waste treatment industries):

$$Limit_1 = \frac{VF_1}{E(X)} \quad (43)$$

to obtain

$$E(X) = \frac{VF_1}{Limit_1} \quad (44)$$

Then, equation 40 (using the estimate of σ^2 from equation 41) and equation 44 can be substituted into equation 42 to obtain:

$$Limit_n = \frac{Limit_1}{VF_1} \left(1 + 1.645 \sqrt{\frac{e^{\sigma^2} - 1}{n}} \right) \quad (45)$$

In particular, for the monthly average limitation based on assuming daily monitoring (i.e., approximately 20 times a month), the limitation is

$$Limit_{20} = \frac{Limit_1}{VF_1} \left(1 + 1.645 \sqrt{\frac{e^{\sigma^2} - 1}{20}} \right) \quad (46)$$

Table 10-8 provides the values of the BOD_5 and TSS limitations and other parameters for the thermosetting resins subcategory from the OCPSF industry and the organics subcategory in the centralized waste treatment industry.

Table 10-8 BOD₅ and TSS Parameters for Organics Subcategory

Parameter	OCPSF: Thermosetting Resins Subcategory		Centralized Waste Treatment: Organics Subcategory	
	BOD ₅	TSS	BOD ₅	TSS
σ	0.6971	0.8174	0.6971	0.8174
Long-Term Average (mg/l)	41	45	41	45
VF ₁	3.97	4.79	3.97	4.79
VF ₃₀	1.58	1.45	n/a	n/a
VF ₂₀	n/a	n/a	1.29	1.36
Daily Maximum Limitation (mg/l)	163	216	163	216
Monthly Average Limitation (mg/l)	61	67	53.0	61.3

Transfer of TSS for Option 4 of the Metals Subcategory

10.8.2.2

For TSS for option 4 of the metals subcategory, EPA transferred the proposed limitations directly from the Metal Finishing rulemaking (see Table 10-9). EPA based the Metal Finishing monthly average limitation for TSS upon an assumed monitoring frequency of ten days per month and the absence of autocorrelation in the measurements. EPA has also assumed an absence of autocorrelation in TSS for the centralized waste treatment industry. However, EPA assumed a monitoring frequency of 20 measurements a month for TSS for the centralized waste treatment industry, rather than the ten measurements assumed in the metal finishing rulemaking. EPA will consider whether it should adjust the monthly average limitation from the metal finishing rulemaking for the increase in monitoring frequency. This adjustment would result in a monthly average limitation with a slightly lower value than presented in the proposal. (The monitoring frequency does not effect the value of long-term averages and daily maximum limitations.)

Table 10-9 TSS Parameters for Metal Finishing

Metal Finishing TSS Values	TSS (mg/L)
Long-Term Average (mg/l)	16.8
Daily variability factor	3.59
Monthly Variability Factor	1.85
Assumed monitoring frequency	10/month
Daily Maximum Limitation (mg/l)	60.0
Monthly Average Limitation (mg/l)	31.0

EFFECT OF GROUP AND POLLUTANT VARIABILITY FACTORS ON LIMITATIONS

10.9

In the preamble to the proposed rulemaking, EPA solicited comment on using pollutant (or ‘pollutant-specific’) variability factors rather than group (or ‘group-level’) variability factors in calculating the limitations. For the 1995 proposed limitations and in today’s proposed limitations, EPA generally used the product of the group variability factor and the pollutant long-term average in calculating each pollutant limitation. For today’s re-proposal, EPA alternatively considered using the pollutant variability factor instead of the group variability factor. (Group and pollutant variability factors are listed in Attachment 10-6.) For pollutants where pollutant variability factors could not be

calculated (due to data constraints), EPA would continue to use the group variability factor.

Using the group variability factor eliminates the extremely low and high pollutant variability factors. Thus, limitations for some pollutants would be more stringent and for others less stringent. Attachment 10-7 provides a listing of the limitations calculated using both methods.

EPA believes that the variability of the pollutants with similar chemical structures would behave similarly in treatment systems; thus, EPA believes that using a single group variability factor may be appropriate for those pollutants. In the preamble to the proposed rulemaking, EPA solicited comment on whether the pollutant or group variability factors or some combination should be used in calculating the limitations to accurately reflect the variability of the pollutants discharged by the centralized waste treatment industry.

ATTACHMENTS

10.10

Attachments 10.1 through 10.7 to this chapter are located in Appendix E at the end of the document.

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